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OBSERVATIONS ON THE EUROPEAN CORN BORER AND ITS MAJOR PARASITES IN THE ORIENT

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CONTENTS

INTRODUCTION

In 1928 the Bureau of Entomology of the United States Department of Agriculture initiated studies in the Orient on the parasites of the European corn borer, *Pyrausta nubilalis* Hbn., with the purpose of introducing into the United States the more desirable species for propagation experiments and for liberation in the field. It is the purpose of this circular to record, in brief, the information obtained by the author on both host and major parasites during 2 years of travel in parts of Japan and China.

P. nubilalis was recognized as a pest of farm crops in Japan as early as 1888, when Hattori[2] made reference to the "awa-no-zui-mushi" or "millet borer", although he mentioned no specific name, and none was used before 1897.[3] Fifty-one articles by Japanese authors, after 1897, give biological accounts of *P. nubilalis* with mention of infestation or damage to nearly 2 dozen plants, including the more important hosts—corn, millet, sorghum, beans, hemp, Chinese indigo, and hops. Prior to 1928 the only record in Japanese literature relating to parasites was one in 1921 by Okamoto[4] in Hokkaido.

Since the information concerning the natural enemies of the borer in the Orient was so meager, a general survey was first undertaken

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[2] Hattori, T. new essays on the insects injurious to field plants. p. 100–101. 1888.

[3] Matsumura, S. gaisho kujo zensho. [control and prevention methods of injurious insects.] p. 237, 241. Tokyo. 1897.

[4] Okamoto, H. life-histories of injurious and beneficial insects in hokkaido. Hokkaido Agr. Expt. Sta. Rpt. 12 : 12–16, illus. 1921.

to locate the habitats of the commoner parasites. The period from June 1928 to June 1930 was spent in scouting important land areas in Hokkaido, Honshu, Shikoku, Kyushu, Okinawa Islands, Taiwan (Formosa), Chosen (Korea), and China (fig. 1), both for borer in-

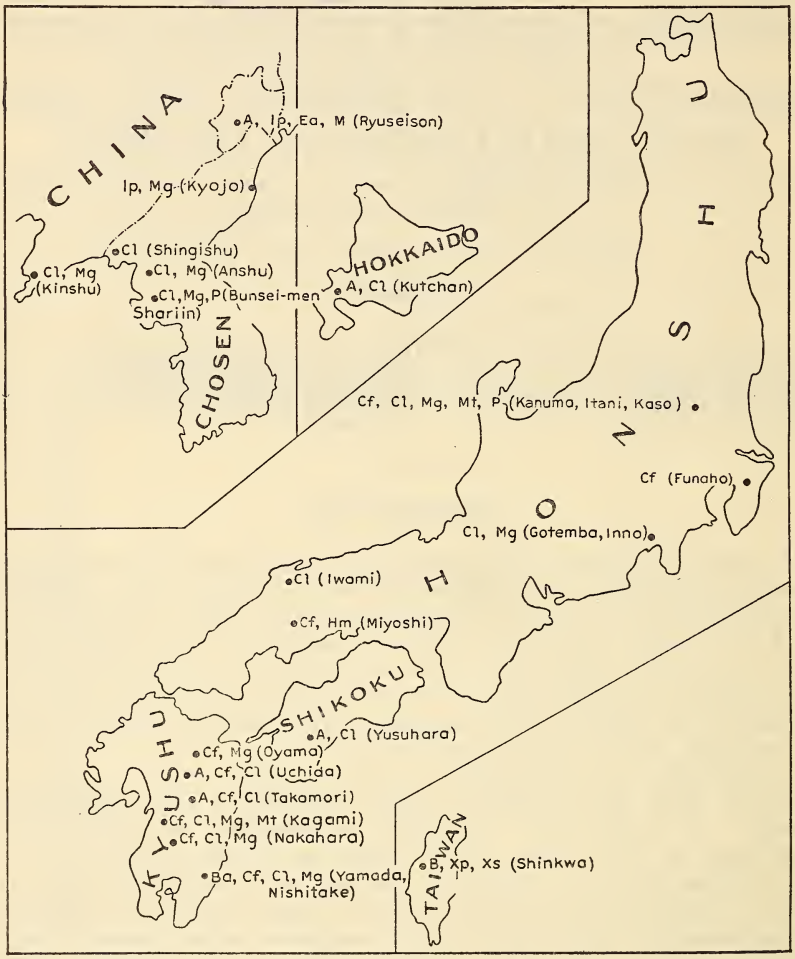

FIGURE 1.—Distribution of the major parasites of the European corn borer in Japan, Chosen, Taiwan, and China. The following symbols indicate the parasites found at the places named in parentheses: A, *Apanteles* sp.; B, *Brachymeria* sp.; Cf, *Cremastus flavoorbitalis;* Cl, *Ceromasia lepida;* Hm, *Hexamermis meridionalis;* Ip, *Inareolata punctoria;* Ea, *Eulimneria alkae;* Mg, *Macrocentrus gifuensis;* Mt, *Microgaster tibialis;* M, *Microgaster* sp.; P, *Phacogenes* sp.; Xp, *Xanthopimpla punctata;* Xs, *Xanthopimpla stemmator.*

festations and for parasites. The discussion of the investigations follows these major geographical divisions.

NOTES FROM HOKKAIDO

The Japanese entomologists agree that one complete generation of *P. nubilalis* regularly occurs in Hokkaido and that a partial second generation is found during favorable seasons. Infestation and dam-

age are recorded principally for corn, millet, hops, sugar beets, hemp, and beans. In 1928 and 1929 borers were found in moderate numbers during October and early November in localities of Iburi Prefecture hibernating in the bamboo poles used in bean fields, where they were concealed in the upper, open ends of the canes; or, in case of the older weathered canes, in the interior of the softened internodes. From the hibernating larvae in beans at Kutchan, two parasites were reared—*Ceromasia lepida* Meig. and *Apanteles* sp., the former predominating. The parasites recorded by Okamoto in 1921, namely, *Exorista tritaeniata* Rond., *Pimpla pyraustae* Mats., and *Eugnomus pyraustae* Mats., were not represented.

In 1929 *Beauveria bassiana* (Bals.) Vuill., a common disease of silkworms throughout Japan, spread disastrously among the confined larvae in the collections of *P. nubilalis* from Hokkaido and also among those from Shikoku, Kyushu, Chosen, and China. Fourteen accounts relating to this disease in the Japanese literature on sericulture between 1888 and 1930 were reviewed, and it was noted that the disease appeared in silkworms from June to early October with especially heavy infections showing in September. The lepidopterous families of Bombycidae, Saturniidae, Pyralidae, Noctuidae, Psychidae, Cochlidiidae, and Lasiocampidae, as well as the Scarabaeidae of the Coleoptera, were reported attacked under field conditions in Japan. The parasitic organisms were believed to live for about 2 years.

NOTES FROM HONSHU

Two and three generations of *P. nubilalis* are recognized in Honshu, with the third generation possibly incomplete for some sections (fig. 2). During 1928 borer collections were made from hemp, millet, and corn in the Prefectures of Tochigi, Chiba, Nagano, Ishikawa, Yamanashi, Shizuoka, Tottori, Shimane, and Hiroshima. The largest collections were made after June, and the generations were not clearly distinguishable, but in hemp and in very early corn and millet one or two generations were indicated, with a distinct third generation in corn and millet. The infestations in hemp ranged from 20 to 50 percent in Tochigi Prefecture in July 1928, and in corn from 15 to 25 percent in the Prefectures of Yamanashi and Shizuoka in September of the same year. In many localities the infestations in the major hosts were too small to justify attempting large collections of borers. In general, larvae and pupae from hemp comprised the collections throughout July and early August, and larvae alone from corn and millet during the months following. No infestations were found in millet, in 1928, in the Prefectures of Aomori and Iwate, or in hemp, in 1930, in the Prefectures of Shiga or Hyogo, but the scouting operations in these Prefectures were limited and incomplete.

The parasitic species in the collections of Honshu comprise the insect parasites *Cremastus flavoorbitalis* (Cam.), *Microgaster tibialis* Nees, *Macrocentrus gifuensis* Ashm., *Phaeogenes* sp., and *Ceromasia lepida*. The pupal parasite *Phaeogenes* sp. occurred only in the rearings from Tochigi. A parasite worm, *Hexamermis meridionalis* Steiner, of the family Mermithidae, was obtained only from Hiroshima.

Cremastus flavoorbitalis was reared sparingly from borers in corn and hemp collected late in July, from hemp in August, and from millet in September. *Macrocentrus gifuensis* was reared in insignificant numbers from hemp in late July and was only moderately abundant from borers in corn in August and September. A single cocoon of *Microgaster tibialis* was noted in a hemp plant in August. *Ceromasia lepida* was rarely found in hemp in late July but was the dominant parasite in borers from corn and millett in August and September. The spring emergence of the hibernating parasites was not noted.

During the last 4 days of July the total parasitization of *Pyrausta nubilalis* did not exceed 2 percent in any one collection from

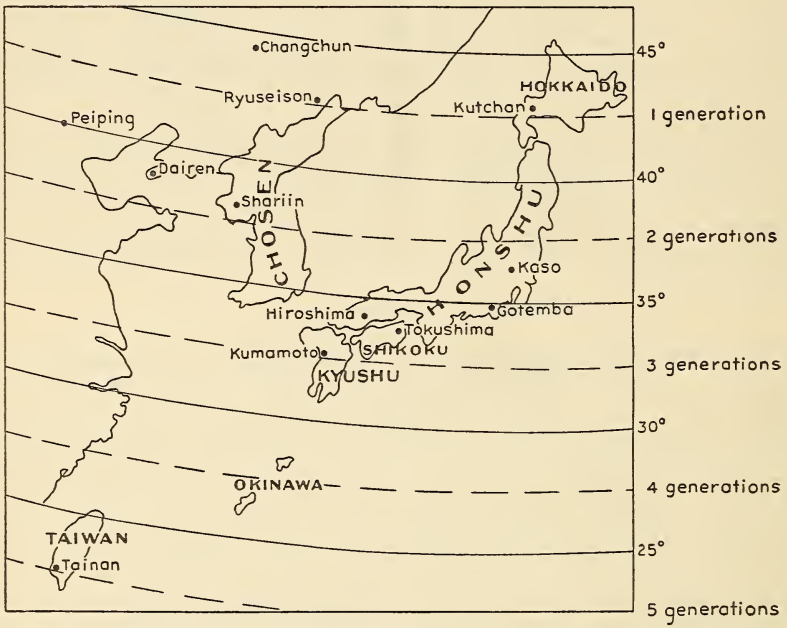

FIGURE 2.—Geographical trend of the generations of *Pyrausta nubilalis* in the Orient.

hemp of Tochigi Prefecture, and the average was less than 1 percent. This general condition prevailed during the rest of the hemp season. In the rearings from millet and corn in August, from the Prefectures of Chiba and Shizuoka, the parasitization increased to a general average of 4 percent with individual rearings showing a 9 percent maximum. The highest parasitization—35 percent—was noted September 13 from 380 corn borers collected at Gotemba, Shizuoka Prefecture. Near the end of September the feeding activities of host larvae came to an end, and no adults of any species of parasites were recorded after October 11. In table 1 is given a summary of the parasites reared in Honshu in 1928. In the case of the gregarious species, all the specimens from a single host were considered as a unit.

TABLE 1.—*Record of the parasites of Pyrausta nubilalis reared in Honshu, Japan, in 1928*

Period	Borers	Parasites found						Borers parasitized
		Cremastus flavoorbitalis	*Ceromasia lepida*	*Macrocentrus gifuensis*	*Microgaster tibialis*	Undetermined	Total	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Percent*
July	2,285	2	2	1	0	1	6	0.3
August	1,558	2	26	4	1	1	34	2.2
September	1,668	1	288	3	0	2	294	17.6

Locality and seasonal records for the species of parasites collected in Honshu during the period July to October, inclusive, 1928, are given here for reference. Parentheses around a date indicate that the specimens were cocoons or puparia.

Cremastus flavoorbitalis: Funaho, October 1; Higashi-oashi, August 11; Minami-oashihara, August 19; Miyoshi, July 27; Ochiai, August 10.

Microgaster tibialis: Itani (August 4).

Macrocentrus gifuensis: Awano, July 27; Fujioka (September 17); Gotemba, August 15–20; Inno (September 13).

Phaeogenes sp.: Kaso, August 8; Kiyosu, August 2.

Ceromasia lepida: Fujioka, September 17–October 11; Gotemba, August 8–28, September 24–October 10; Higashi-oashi (August 3); Inno, September 16–October 7; Iwami, August 15–31; Namma (July 30); Ochiai (July 30).

NOTES FROM SHIKOKU

Three generations of *P. nubilalis* are reported for the Island of Shikoku with major infestations in Chinese indigo and corn. In September 1929, collections were made from the major corn belt in the Prefecture of Kochi, near the towns of Shinden and Yusuhara, where *C. lepida* and *Apanteles* sp. were recorded from hibernating larvae; and, in November, from stems of Chinese indigo in the Prefecture of Tokushima, near Tokushima. The infestations were small and large collections were difficult to obtain.

NOTES FROM KYUSHU

The Prefectures of Nagasaki, Fukuoka, Kumamoto, Miyazaki, and Kagoshima furnished many localities for borer studies from 1928 to 1930 (fig. 3). Three generations were readily recognized as occurring in the lowlands and plateaus of the island, with a probable partial fourth generation in some of the warmer portions, and a possible reversion to two major generations in the colder mountainous areas. Several facts of interest may be enumerated: First-generation larvae were found infesting hemp in June in the lowland areas; pupation in hemp in the lowlands was under way by June 10; infestation was general in hemp in the higher areas in July and August, with pupae present throughout July and August; and larvae of various sizes were found infesting corn and millet in Sep-

tember and October. Harvesting of the lowland hemp was completed by early July, whereas in the highlands the harvest period extended from the middle of July to the third week of August. Considering both fiber and seed hemp, there was a continuous infestation, with pupae present from early June throughout late August. Although there was much overlapping, two generations were indicated in hemp and a third in corn and millet. In the high moun-

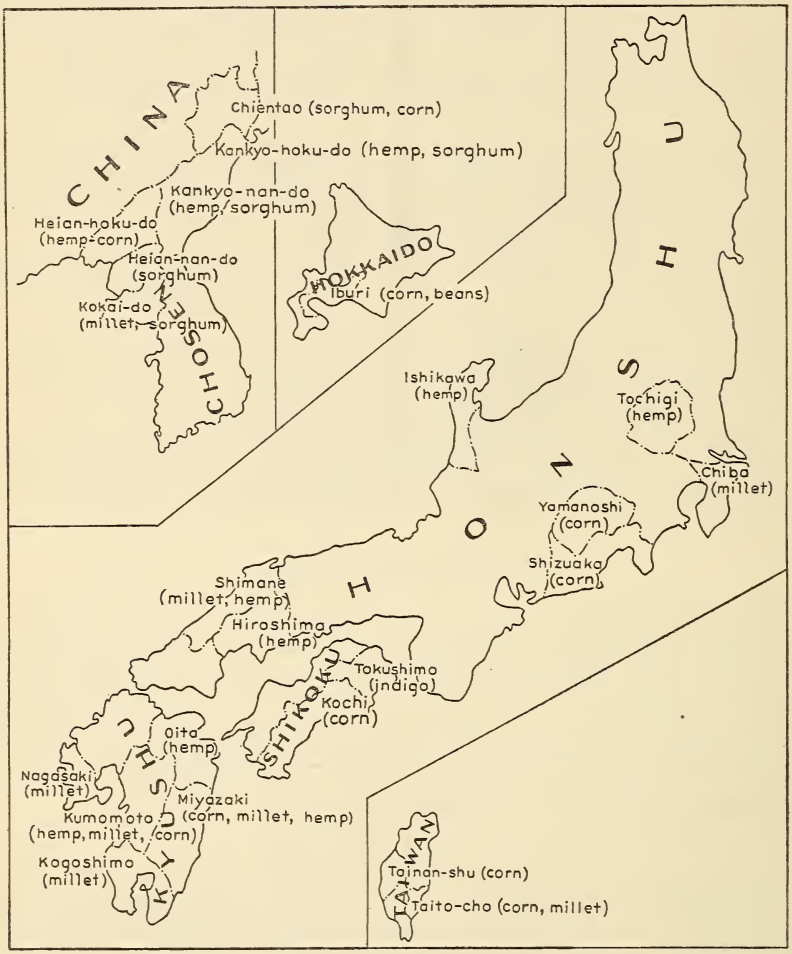

FIGURE 3.—Research centers in the Orient with the corn borer's major host plants.

tain section this separation of generations was not apparent, a single generation for hemp and one for corn being indicated.

The combined acreages of the major hosts in the Prefectures surveyed in 1928 were estimated to be 1,500 of hemp, 20,000 of corn, and 120,000 of millet.

The infestations in hemp were moderately heavy, causing economic damage throughout Kyushu. From 5 to 78 percent of the hemp plants were infested in June and July, with a general average of

28 percent. Migration of the larvae within an infested field prevented exact counts, but most infested plants showed from 1 to 3 larvae.

The infestations in millet in September and October in the large acreages of Kumamoto and Nagasaki were light. Plant samples having no infestations were frequent. A maximum infestation of 15 percent was noted in one sample of 300 plants obtained October 4, but the average infestation for Kyushu did not exceed 4 percent. The stored millet stalks of Miyazaki Prefecture, from which the best winter collections of larvae for shipping were made, showed from 0 to 25 percent of the plants infested with from 1 to 3 larvae and indications of previous migration of borers as above noted for hemp.

No serious economic damage to corn was noted in 1928 in the Prefectures of Kumamoto and Miyazaki, although counts of selected samples showed the infestations to range from 3 to 31 percent. Usually only one or two larvae were found in an infested plant, the tassel and ears being most noticeably infested. The heaviest infestations occurred after September 15. A 17 percent infestation of one larva per plant was recorded in November in the highland area near Mount Aso in stored stalks and stubs of corn.

As the research did not begin until June, the field emergence of the parasites from hibernation was not noted in 1928. The earliest collections of borers from growing hemp, on June 11, showed parasitization by *Cremastus flavoorbitalis*, *Microgaster tibialis*, and *Ceromasia lepida*. Parasitization by *Macrocentrus gifuensis* appeared in the June 16 collections. *Cremastus* was the dominant parasite of the borers from hemp in June, *Macrocentrus* in July, and *Ceromasia* in August. Unfortunately the September observations were too incomplete for analysis. The hemp season had ended by this time, and the immature larvae in millet and in corn could not readily be examined for parasites. *Ceromasia* and *Macrocentrus* were reared from borers of corn and millet in October, and *Apanteles* sp. from borers from corn. Four specimens of *Bracon atricornis* Smith were reared in August from borers in millet in Miyazaki Prefecture.

There was a constant emergence of *Cremastus flavoorbitalis* from borers in growing hemp during the period from June 19 to July 10 in the lowlands, which roughly coincided with the presence of the first generation of *P. nubilalis*. A few adults of *Cremastus* in the periods July 17–23 and August 10–20 belonged to the first upland generation, and the second lowland and irregular second upland generations respectively. The natural habitat of *Macrocentrus gifuensis* was the upper slopes, ravines, and valleys, and for this reason there was only an occasional emergence from borers in hemp in June. The individuals of early July belonged to the first upland generation, which reached its maximum strength in the period July 19–27, coincident with the heaviest infestation by the first generation of borers in upland hemp. The adults noted August 19–27, and occasionally during October, were considered to be of successive or partial generations. *Ceromasia lepida* was distributed from sea level to above 2,000 feet altitude. There were four periods of emergence during 1928 exclusive of the emergence from hibernation: June 24–July 5, July 16–28, August 10–September 11, and October 24–Novem-

ber 17, with moderate peaks on June 27, July 24, August 20, and November 1, respectively. The synchronization of *Ceromasia* with its host is to be inferred from the corresponding emergence periods in the discussions of *Cremastus* and *Macrocentrus*. These three parasites were observed in hibernating larvae from millet stalks in the Prefecture of Miyazaki.

In the southern plateaus of Miyazaki Prefecture there was no strict hibernation of the borers, and from October to March newly formed puparia of *Ceromasia* were noticed in millet stalks. Hyperparasitization was recorded for *Cremastus* in June and for *Macrocentrus* in July, and was relatively high for *Ceromasia* in the field in August. Old puparia in the winter collections showed immature forms of the secondaries within them.

The aggregate parasitization for borers in hemp for June, July, and August was 10, 4, and 1 percent, respectively, in individual rearing samples of 60 to 2,800 borers, which showed a range of from 0 to 22 percent parasitization. Parasitization in the October rearings averaged 2 percent, with a maximum of 10 percent; but owing to the lateness of the season the completeness of the records may be questioned.

In the fields of millet and corn an associated borer, *Sesamia inferens* Walk., was present. This sluggish borer was noted in several localities in Kyushu as well as in Honshu, in Shikoku, and in Okinawa Island. In some of the millet fields it was more numerous than *P. nubilalis* and was equally responsible for the damage evident. In corn, it was particularly noticeable in the ear at harvest time.

In 1928 more than 95 localities in Kyushu were scouted and approximately 26,500 larvae collected for rearing experiments. Table 2 gives a record of the reared parasites by species.

TABLE 2.—*Parasites of Pyrausta nubilalis reared in Kyushu, Japan, in 1928*

Period	Borers	Parasites found						Borers parasitized
		Cremastus flavoorbitalis	*Ceromasia lepida*	*Macrocentrus gifuensis*	*Microgaster tibialis*	Undetermined	Total	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Percent*
June	1,565	120	31	2	1	5	159	10.2
July	10,804	17	99	343	6	0	465	4.3
August	11,427	1	102	46	0	4	153	1.3
October	2,695	0	46	5	0	4	55	2.0

Locality and seasonal records for the species of parasites collected in Kyushu for the period June to October, inclusive, 1928, are given here for reference. Parentheses around a date indicate that the specimens were cocoons or puparia.

Cremastus flavoorbitalis: Kagami, June 19–July 6; Kawakami, July 4–10; Mitai, August 10–11; Nakahara, June 27–July 4, July 17–23; Nishitake (Aug. 11); Nishizato, June 30–July 12; Omura, July 3–5; Oyama (July 22); Takamori (Aug. 26); Uchida, June 26–July 7; Uyeki, August 11–20; Waifu, June 24–July 8; Yamada (August 14); Yamae (June 16).

Macrocentrus gifuensis: Iwato (July 16); Kagami, July 26; Mitai, July 28; Nakahara, July 3–27; Nishitake, August 11; Yamae, August 19–27, October 9, (November 1); Oyama (July 22).

Microgaster tibialis: Iwato, July 26–29; Kagami (June 11); Mitai, July 26–August 3.

Apanteles sp.: Takamori (Aug. 26); Uchida (June 16).

Ceromasia lepida: Isoichi, August 18–28; Iwato, July 26–28; Kagami, June 24–27; Kashiwa (October 24); Kawakami, July 5; Mamihara (October 18); Mitai, July 24–27; Nakahara, June 27–July 1, July 16–24; Nishitake, August 13–28; Nishizato, July 5 and July 15; Okimizu, August 11–22; Omura, June 27–July 1; Oyama (July 22); Sangasho (October 22); Shimabara, November 1, 17; Shonai, August 11–22; Sugeo (October 25); Takajyo, August 13–28; Takamori, September 3–11; Takazaki, August 18–22; Uchida, June 27–July 1; Uyeki, August 11–20; Waifu, June 14; Yamada, August 11–20, October 29–November 5; Yamae, July 17–24, August 18–28; Yamano-kuchi, August 23.

NOTES FROM OKINAWA ISLANDS

Short trips were made from Okinawa Island in April 1930. The fields of millet found were uninfested by *P. nubilalis* but were infested by *Sesamia* sp. A few specimens of Sesamia were also noted in sugarcane on Oshima Island. In the Okinawa group of islands there were estimated to be 5,000 acres of millet, 550 acres of dwarf sorghum, 1,400 acres of seed sorghum, and about 2 acres of corn.

NOTES FROM TAIWAN (FORMOSA)

A circuit was made of Taiwan in March and early April 1929. As a whole, very few infestations of *P. nubilalis* were located, as its host plants were not extensively grown. Corn on the lowlands near Daiwan, Kagi, Tainan, Shinkwa, and Shinyei of Tainan-shu, was slightly infested; but millet, which was grown in small acreages in the mountainous section near Jujiro, of the same Province, was uninfested. Neither the lowland cornfields near Takao and Boryo nor the mountain fields of millet near Shirinkaku, Kusukusu, and Botansha of Takao-shu were infested, but corn and millet near Taito, Taitocho Province, were infested. Pupae were found in growing corn March 18–28 at Daiwan, Kagi, and Taito, and continuous infestations were present, with likelihood of more than five generations of *P. nubilalis* a year. In May, 1929, M. Yanagihara of the Shinkwa Experiment Station continued cooperative observations on *P. nubilalis* at Shinkwa and recorded adults, judged to be of the second generation, May 3 to 19.

Xanthopimpla stemmator (Thunberg), *X. punctata* (Fab.), and *Brachymeria* sp. were found as pupal parasites of *P. nubilalis* in May 1929, at Shinkwa. One of the species of *Xanthopimpla* was reared March 27 and April 13 from an undetermined pyralid borer of thistle at Korin, Takao-shu. *X. punctata* was held tentatively as a parasite of *Diatraea striatalis* Snell., *Chilo infuscatellus* Snell., and *Eucosma schistaceana* Snell. infesting sugarcane in Tainan-shu. *Brachymeria* sp. was also a parasite of *Eucosma schistaceana.* Lar-

val parasites of *P. nubilalis* for the Taito and Shinkwa sections await determination.

NOTES FROM CHOSEN (KOREA)

Research was begun in western Chosen in April 1929, and later in the year was extended to include northern Chosen. The purpose, for the year, was primarily to determine major points for making winter collections. The notes made on *P. nubilalis* during the research are, as a whole, disconnected; but they indicate a minimum of two generations of the borer for the western Provinces of Kokai-do, Heian-nan-do, and Heian-hoku-do, and for the northern Provinces of Kankyo-nan-do, with a probability of the generations becoming irregular and incomplete in the northern Province of Kankyo-hoku-do. The first generation was principally in hemp and millet in late June and July and the second generation in corn and sorghum after July in the first four Provinces mentioned. The host relationship and the number of generations for Kankyo-hoku-do were not determined, except that hemp is infested in the mountainous sections of this Province in late July and corn, sorghum, and millet later.

Pupae of hibernating larvae from sorghum were found in late May and early June in the central part of Chosen; by June 6 about half of the borers had pupated. From July 9 to 31 pupae of the first generation were found in growing millet and hemp. Larvae were still in hibernation in the northern Province of Kankyo-hoku-do June 18. An associated pyralid borer was hibernating in millet stubs in the Province of Kokai-do, the progeny of which infested millet in May.

In April and May, samples of from 50 to 200 stalks of stored sorghum were examined in northern and western Chosen for infestations of *P. nubilalis*, which were found to range from 0 to 40 percent, with a general average of 10 percent, for several hundred stalks examined and to have about 1 larva per infested plant. Less than 4 percent of the growing millet plants of Kokai-do were infested in July, with many examinations showing only occasional infestations. Hemp was not heavily infested near Shariin, in this Province, in July, but a heavy infestation with practically a complete loss of the crop was found July 5 in one field at Shingishu of Heian-hoku-do. Hemp was regularly reported infested in July, with economic damage in the southern Chosen Province of Kogen-do and the northern Chosen Provinces of Kankyo-nan-do and Kankyo-hoku-do. Hibernating larvae were found in sorghum and millet stalks in the Province of Kankyo-hoku-do.

The parasitization by all species for approximately 20,000 hibernating sorghum borers was 3.5 percent, with individual rearings of 30 to 3,200 larvae showing a range of 0 to 15 percent parasitization. Of 1,100 parasites (including reared and field specimens) from borers hibernating in sorghum, approximately 93 percent were *Ceromasia lepida*, 6 percent *Macrocentrus gifuensis*, and the remainder distributed among *Inareolata punctoria* Roman, *Apanteles* sp., and undetermined parasites. Adults of *Ceromasia* emerged from hibernation in western Chosen from May 22 to July 6, with a constant emergence June 3 to 15 without a definite peak, yet representing 75

percent of the individuals. The next generation of adults appeared in the field July 18 to 29, but its extent and later development were not followed. A 12 percent parasitization by *Ceromasia* occurred in July at Shariin.

M. gifuensis emerged from borers hibernating in sorghum in western Chosen during the period June 6–27, with the greater emergence after June 10. In northern Chosen emergence was evident July 15. Later development was not followed in Chosen. *I. punctoria* was reared from borers hibernating in sorghum collected June 25 and 26 in northern Chosen, with emergence during the period July 24–29. *Phaeogenes* sp. was reared from pupae found in growing millet at Bunsei-men, Kokai-do Province, July 31. *Apanteles* sp. was reared from borers hibernating in sorghum in western Chosen May 27, and in northern Chosen June 3 and June 17.

Secondary parasites were reared from *Ceromasia* from May 19 to June 4, and from *Inareolata* on July 18. In the laboratory, a second generation was reared from *Ceromasia* with emergence of adults July 1–25.

In table 3 is given a summary of the parasites reared in Chosen in 1929.

TABLE 3.—*Parasites of Pyrausta nubilalis reared in Chosen in 1929*

Period	Borers	Parasites found					Borers parasitized
		Ceromasia lepida	*Macrocentrus gifuensis*	*Inareolata punctoria*	Undetermined	Total	
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Percent*
April	356	18	0	0	0	18	5.1
May	19,691	578	76	0	1	655	3.3
June	243	0	9	5	1	15	6.2
July	147	18	0	0	0	18	12.2

Locality and seasonal records for the species of parasites collected in Chosen for the period are given here for reference. Parentheses around a date indicate that the specimens were cocoons or puparia.

Macrocentrus gifuensis: Anshu, June 8–22; Banjo, June 6–18; Bunsei-men (June 6); Kanko, July 15; Kyojo (June 26); Seikei, June 12; Seisho-men, June 6–14; Shinanshu, June 8–27.

Apanteles sp.: Banjo, May 27; Kwainei, June 3; Kyojo, June 17.

Phaeogenes sp.: Bunsei-men, July 31.

Inareolata punctoria: Kyojo, July 24–29.

Ceromasia lepida: Anshu, May 24–June 26; Banjo, May 22–June 21; Bansei-men, May 24–June 21; Bunsei-men, May 28–July 6, July 18–29; Do jo-men, June 1–28; Junsen, May 19; Kwainei, June 5–12; Sansui-men, June 5–18; Seikei, May 30–June 28; Seisho-men, May 30–July 1; Shariin, June 5–24; Shariin-men, May 31–June 28; Shinanshu, May 31–June 27; Shingishu, July 17–19; Soga-men, May 28–June 27.

Undetermined Hymenoptera: Anshu, May 27, June 12–14 (probably *Eulimneria* sp.); Banjo, June 10 (probably *Cremastus* sp.); Bunsei-men, June 1; Sansui-men, June 5.

NOTES FROM CHINA

The Manchurian Provinces of Kirin, Mukden, and Amur have land areas of 90,224, 81,018, and 211,385 [5] square miles respectively—approximately the aggregate areas of Texas and New Mexico. Soybeans, sorghum, corn, millet, wheat, barley, oats, and rice are the staple plant crops. Kirin and Mukden were visited in the corn-borer search.

Across the Chosen border by way of Kankyo-hoku-do into Kirin Province, heavy infestations of *P. nubilalis* were found in 1929 and 1930. In the section known as Chientao, or Kanto, wherein are the towns of Ryuseison, Dobutsuji, and Hachidoko, it was estimated there were 50,000 acres each of corn and sorghum. On September 7, 1929, infestations in sorghum ranged from 33 to 56 percent, with usually only one larva, occasionally two, per infested plant; the infestation not being considered of economic importance by the farmers. In corn the infestation ranged from 74 to 100 percent, with an average of about 3 larvae per infested plant, and a maximum of 19 in one plant at Ryuseison. Sweet corn was most seriously damaged.

The borer hibernated in corn, sorghum, and millet, which are used as fuel, stock feed, windbreaks, fences, lathing, or roofing. The clean-up of refuse after the winter season was not so complete in Chientao as in Chosen, and this may account for the heavier infestations in the major hosts in the Chientao district. Observations here indicate one principal generation and a partial second generation of borers each year. Pupation of hibernating larvae began June 25 in 1929. A few larvae of the third instar were present with the mature larvae in late September of this year, and one pupa was noted August 15, when 256 larvae were found in corn. No infestations were observed in the young plants of corn, sorghum, and millet in June.

In 1929 approximately 20,000 mature larvae from Chientao were confined in rearing cages, but *Beauveria* killed most of these before definite data on parasitization were obtained. One lot of 912 hibernating larvae, collected from sorghum June 19, yielded 75 adults of *Inareolata punctoria* but no other parasite. Cocoons of *Inareolata* were present in the field from this time to July 11, two being noted in the field August 21, from which adults emerged August 29. A few adults were present in the field to September 13.

Twenty cocoons of *Eulimneria* sp. and one of *Microgaster* sp. were found in cornstalks September 10, 1929. From this date until May 17, 1930, cocoons of *Eulimneria* were numerous in sorghum, but cocoons of *Microgaster* were few. Eighty-eight *Eulimneria* cocoons collected in September from sorghum had no secondary parasites. An examination of 1,500 sorghum stalks May 14, 1930, yielded 134 cocoons of *Eulimneria*, with emergence of adults then progressing. *Microgaster* was also emerging in the field at this time. Dissections of 200 and 130 cocoons, respectively, of *Eulimneria* and *Microgaster* showed 66 and 32 percent, respectively, with dead larvae and 2 percent with secondary parasites. The dead specimens

[5] South Manchuria Railway. report on progress in manchuria 1907–28. p. 11, illus. 1929.

of both *Eulimneria* and *Microgaster* showed symptoms of *Beauveria* and of bacterial wilt, then prevalent in *P. nubilalis* in the field.

A single puparium of *Ceromasia lepida* was found September 19, in corn, and many larvae of this species emerged from borers from sorghum in the warm laboratory in January and February. *Apanteles* sp. emerged at the same time from larvae hibernating in sorghum.

The second Manchurian Province traveled was Mukden. Borers were found at Yugakujo and at Kinshu, of the Dairen district, and at Kaigen, Koshurei, and Changchun, of the Changchun district. The former is considered a 2-generation area and the latter primarily a 1-generation area with respect to *P. nubilalis*. In July 1929, records in the Dairen district showed corn 100 percent infested, sorghum 20 percent, and millet 10 percent. A few infested plants of corn and of millet were found in July at Changchun. During the period July 12–16 collections from growing millet and corn were made in these districts. *Ceromasia lepida*, *Macrocentrus gifuensis*, and *Inareolata punctoria* were reared from the borers in corn and *C. lepida* and *I. punctoria* from those in millet. The combined parasitization did not exceed 6 percent for an individual collection. Secondary parasites were reared from *C. lepida* at Yugakujo and at Kaigen.

Research in China proper was limited to the Tientsin and Peiping sections. Corn was heavily infested July 11 at Peiping with larvae ranging in size from small to full grown. *Ceromasia* and *Macrocentrus* were noted at Peiping. Secondaries were recorded for *Ceromasia*.

Locality and seasonal records for the species of parasites collected in China are as follows, with dates in parentheses indicating cocoons or puparia.

Ceromasia lepida: Dobutsugi (June 1); Kaigen, July 23–26; Kinshu, July 20–23; Koshurei, July 24–28; Peiping, July 19–24; Ryuseison, June 1; Yugakujo, July 23–26.

Microgaster sp.: Ryuseison, May 14–17.

Macrocentrus gifuensis: Kinshu, July 28–30; Peiping, July 24–25; Yugakujo, August 2–5.

Apanteles sp.: Ryuseison, May 17.

Inareolata punctoria: Kaigen, July 28; Kinshu, July 24; Ryuseison, July 1–26, August 28–29; Yugakujo, July 25.

Eulimneria alkae E. and Sacht.: Ryuseison, May 14–17.

Undetermined Hymenoptera: Ryuseison, May 17–27, September 4.

SUMMARY

Pyrausta nubilalis Hbn. was found in Hokkaido, Honshu, Kyushu, Taiwan, Chosen, and eastern China during the research of 1928–30. Infestations were evident in these territories in one or more of the major host plants such as corn, millet, sorghum, hemp, beans, indigo, and hops.

Parasites of *P. nubilalis* included *Apanteles* sp., *Bracon atricornis* Smith, *Brachymeria* sp., *Ceromasia lepida* Meig., *Cremastus flavoorbitalis* (Cam.), *Hexamermis meridionalis* Steiner, *Inareolata punctoria* (Roman), *Eulimneria alkae* E. and Sacht., *Macrocentrus gifuensis* Ashm., *Microgaster tibialis* Nees, *Phaeogenes* sp., *Xanthopimpla punctata* (Fab.), and *Xanthopimpla stemmator* (Thunberg).

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